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(71) Applicant: **VARIAN ASSOCIATES, INC.**
611 Hansen Way
Palo Alto, CA 94303(US)

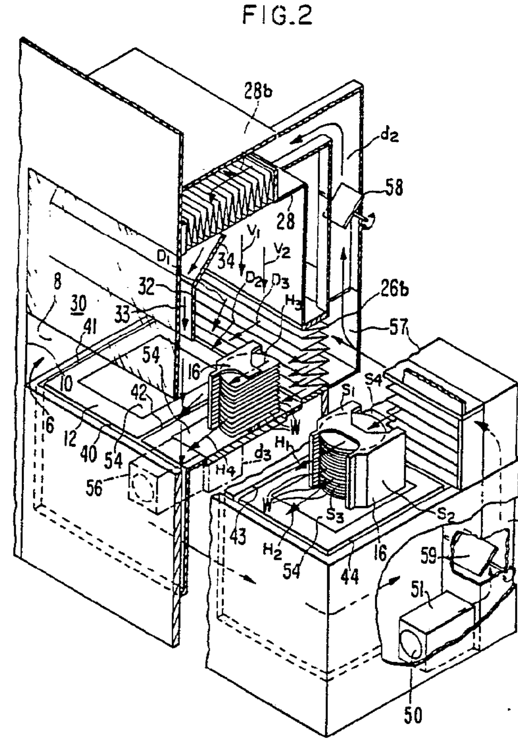
(72) Inventor: **Mears, Eric Loring**
Andrew's Hollow
Rockport, MA(US)
Inventor: **Jennings, Robert E.**
15 Cassimere Street
Andover, MA 01810(US)

(74) Representative: **Cline, Roger Ledlie et al**
EDWARD EVANS & CO. Chancery House
53-64 Chancery Lane
London WC2A 1SD(GB)

(54) **Horizontal laminar air flow work station.**

(57) A load chamber of a load lock is provided with a vertical air curtain which isolates the load chamber from the general clean room environment. Horizontal air flows generated in the load chamber bathe wafers held horizontally in the chamber with filtered air. These horizontal air flows are captured by the air curtain and recirculated to filters which provide horizontal and vertical air flows in the load chamber. If desired, the vertical and horizontal flows may be driven by the air supply mechanism of the clean room itself.

FIG.2



EP 0 319 145 A2

HORIZONTAL LAMINAR AIR FLOW WORK STATION

This invention relates to semiconductor processing equipment and, in particular, to a load chamber providing selected air flow patterns for reducing particulate contamination.

As the trend toward higher device densities and smaller device geometries continues, particulate contamination has become an increasingly important problem. As is well known, a single particle on the order of one micron in diameter deposited on the surface of a semiconductor wafer can cause the loss of the entire wafer. One prior art approach to solving the particulate contamination problem has been to provide clean rooms for semiconductor processing. In the typical clean room, laminar air flows are generally directed downward from the ceiling of the clean room toward either floor or wall exhausts. The laminar air flows bathe the operator and the semiconductor equipment in filtered air. In some clean rooms, horizontal air flows from one clean room wall to an opposed clean room wall are provided.

The general approach of providing filtered air flows in clean rooms does not, however, solve the problem of particulate generation in areas which, by equipment design necessity, are sheltered from the clean room air flows. Once such area is the loading chamber region of many machines incorporating vacuum load locks. The load chamber is located externally of the load lock in the region adjacent the entrance to the load lock.

The present invention provides a load station for semiconductor processing apparatus which includes a load chamber having means for generating a horizontal flow of filtered air to bathe wafers held in the load chamber while simultaneously generating a vertical air curtain which flows across the entrance opening of the load chamber to isolate the horizontal flow generated in the load chamber from the clean room. In this manner the laminar downward flow of air in the clean room is not disturbed by the horizontal flow in the load chamber and the wafers in the load chamber are protected from particulate generation in the region above the wafer cassettes in the load chamber by the horizontal air flow.

In addition to the vertical air curtain, a laminar flow of filtered air directed vertically downward is also generated above the wafer cassettes, so that there are no regions of stagnate air in the load chamber. The horizontal flow merges with the vertical laminar downward flow. Air return slots are provided in the lower surface of the load chamber.

FIG. 1 shows a schematic perspective view of one embodiment of the load station of the present invention in the context of a semiconductor clean room;

FIG. 2 shows a more detailed partially cut away perspective view of the embodiment shown in FIG. 1; and

FIG. 3 shows a partially schematic cross-sectional view of an alternative embodiment of the load station of the present invention.

FIG. 1 shows a schematic perspective view of one embodiment of load station 1 of the present invention in the context of semiconductor clean room 3. Operator 2 controls processing parameters via control panel 4. In the embodiment shown in FIG. 1, load chamber 6 of load station 1 has a generally rectangular shape bounded by table 12, side walls 7 and 10, back wall 26 and ceiling wall 28 (FIG. 2). Front opening 8 of load station 1 connects load chamber 6 to clean room 3 and provides access to wafer cassettes 16, only one of which is shown in FIG. 1, by operator 2 and/or cassette transfer apparatus (not shown) in clean room 3.

Load lock chambers 20 are located beneath load lock covers 17, one of which is shown in its elevated position in FIG. 1. Load lock covers 17 are raised and lowered on tracks 19 by conventional mechanisms (not shown). When wafers W in cassettes 16 are to be processed, cassettes 16 are lowered into load lock chambers 20 by elevator means (not shown). Wafers are then transferred from cassette 16 by transfer mechanisms (not shown) to wafer processing equipment (not shown), for example, ion implantation equipment, which is located in a vacuum chamber (not shown) which communicates with load locks 20 and which is vacuum isolated from clean room 3 by load lock chambers 20.

FIG. 2 shows a perspective view of load chamber region 6 of load station 1. Table 12 includes three elevator platforms 54, each of which supports a wafer cassette 16 (only two of which are shown in FIG. 2). Platforms 54 are lowered by elevator mechanisms (not shown) to load cassettes 16 into chambers 20. Cassettes 16 include side walls S_1 and S_2. Grooves (not shown) in side walls S_1 and S_2 support wafers W in a generally horizontal orientation in wafer cassettes 16. Front S3 and back S4 of cassette 16 are open and permit passage of horizontal air flows between wafers W in cassettes 16 as indicated by arrows H_1, H_2, H_3 and H_4, from horizontal air filter 26b recessed in back wall 26 toward front opening 8. Preferably, the vertical ex-

tent of horizontal air filter 26b is somewhat greater than the height of cassette 16. In one embodiment filter 26b is a HEPA filter.

Table 12 includes air return slots 40 through 44 which run along the top edges of Table 12 and between cassettes 16. Air return slots 40-44 are connected by duct work (not shown) of conventional design to air intake 50 of blower 51. Air from blower 51 is communicated via duct d_1 to horizontal air filter 26b and via ducts d_1 and d_2 to vertical air filter 28b recessed in ceiling wall 28 of load chamber 6. Plates 32 and 34 attached to end walls 7 and 10 form, together with front plate 30, a generally vertical passage 33 which directs a curtain of filtered air vertically downward from air filter 28b across front opening 8 to air return slot 40 which runs along the front edge of table 12. Plate 34 slopes inward to channel flow from vertical air filter 28b and to accelerate the flow into vertical passage 33.

In operation, air blower 51 drives air via duct d_1 to horizontal air filter 26b. Horizontal air flows from air filter 26b, indicated schematically by arrows H_1 through H_4, pass between wafers W in cassettes 16 from air filter 26b toward front opening 8. Air blower 51 also drives air via ducts d_1 and d_2 to vertical air filter 28b. A first portion of filtered air from vertical air filter 28b flows downward into load chamber 6 as indicated schematically by arrows V_1 and V_2 and converges with air flowing horizontally from air filter 26b to form diagonal flows indicated schematically by arrows D_1 through D_3 in FIG. 2. This convergence occurs in a non-turbulent manner. Horizontal air filter 26b extends sufficiently far above the tops of cassettes 16 that these diagonal flows approach the horizontal above the tops of wafer cassettes 16. A second portion of filtered air from vertical air filter 28b flows downward through vertical passage 33 and generates a vertical curtain of filtered air, typically of higher velocity than the first portion, flowing across opening 8 to air return slot 40 which runs along the front edge of table 12. This vertical curtain of laminar air also has higher velocity than horizontal flows V_1-V_4 and captures the horizontal flows V_1-V_4 and directs them into air slot 40. The horizontal flows do not penetrate the vertical curtain of air because of velocity and inertial differences, and hence the generally vertical downward flow (generated by conventional means not shown) which is typically present in clean room 3 is isolated from, and thus not disturbed by, the horizontal flows present in load chamber 6 of load station 1.

In the event that operator 2 or automated equipment (not shown) in clean room 2 breaks the air curtain, the horizontal flows H_1-H_4 of filtered air bathing wafers W, flow toward operator 2 so that particles generated by operator 2, particularly particles which are generated by operator 2 in load chamber 6 above wafer cassettes 16 are carried away from wafers W and do not contaminate the surfaces of wafers W.

Narrow slots 41, 42, 43 and 44 draw in both horizontal air flows and vertical air flows between wafer cassettes 16 and between wafer cassettes 16 and side walls 7 and 10 so that there is no net exchange of air between clean room 3 and load chamber 6.

As shown by the dotted lines in FIG. 2, in one alternate preferred embodiment, two separate air blowers 56 and 51 draw air from slots 40-44 and pressurize both sides of duct 57. This arrangement provides greater flow volume more evenly distributed along duct 57. Dampers 58 and 59 may be turned to adjust relative vertical and horizontal flow velocities.

Alternatively, in another embodiment, the output of blower 51 may be connected to filter 26b by a first duct (not shown) and the output of blower 56 may be connected to filter 28b by a second duct (not shown) disjoint from the first duct. The relative speeds of the horizontal and vertical flows can then be adjusted by adjusting the speed of the individual blowers.

The embodiments shown in FIG. 2 are advantageous in that they are simple, self-contained units which recirculate filtered air. However, in the absence of air cooling and humidification devices, which may be employed if desired, the temperature of the recirculated air may tend to rise and there may be a concomitant decrease in the humidity of the recirculating air. Also, static charge may build up on wafers W causing damage to the delicate semiconductor devices on wafers W in the presence of very dry moving air.

FIG. 3 shows schematically yet another embodiment of the invention which is similar to FIG. 2, except that ducts d_1 and d_2 are not present. In the embodiment shown in FIG. 3, duct 60 is provided which is adapted to be connected to clean room air supply means 80 which supplies filtered air to clean room 3. Air supplied by air supply means 80 is conveyed from duct 60 to vertical air filter 28b via branch duct 62 and to horizontal air filter 26b via branch duct 61. Air return duct 63 connects slots 40-44 to air blower 75 whose output end 76 is adapted to be connected to air intake duct 81 connected to clean room air supply 80. Flow control dampers 70, 71, 72, and 73 in ducts 60, 61, 62 and 63 respectively control the flow rate in their respective ducts.

This latter embodiment has the advantage that fully conditioned, humidity controlled filtered air from clean room air supply 80 is supplied to load chamber 6, which obviates any potential heat or static charge build-up problem.

The embodiment shown in FIG. 3 requires damper balance to adjust the vertical and horizontal flow rates. The embodiment shown in FIG. 3 is compatible with the embodiments shown in FIG. 2 in the sense that same hardware and blowers can be used with changes only to the ducts d_1 and d_2.

In another embodiment similar to that shown in FIG. 3, air blower 75 is not present and duct 63 is connected directly between air return slots 40-44 and air intake duct 81 of clean room air supply 80.

The above embodiments are meant to be exemplary and not limiting, and in view of the above disclosure many modifications will be obvious to one of ordinary skill in the art without departing from the scope of the invention.

Claims

1. A load station for semiconductor wafers comprising:
a chamber having an opening;
means for supporting at least one cassette for holding semiconductor wafers in said chamber; and
channel means for directing a horizontal flow of air in said chamber directed toward a cassette supported by said means for supporting and toward said opening and for directing a curtain of air flowing vertically downward across said opening.

2. A load station as in claim 1 wherein said channel means includes means for filtering said horizontal flow of air and means for filtering said curtain of air.

3. A load station as in claim 1 wherein said channel means includes means for directing air to flow vertically downward in said chamber in addition to said curtain of air.

4. A load station as in claim 1 further including means for generating said horizontal flow of air and for generating said curtain of air.

5. A load station as in claim 4 wherein said means for generating comprises two air blowers in parallel.

6. A load station as in claim 4 wherein said means for generating comprises a first air blower for generating said curtain of air and a second air blower for generating said horizontal flow.

7. A load station as in claim 4 wherein said means for supporting includes means for supporting a plurality of cassettes for holding semiconductor wafers and said channel means comprises a slot located between at least two of said means for supporting for returning air to said means for generating.

8. A load station as in claim 1 wherein said chamber comprises a generally horizontal lower surface and said channel means for directing comprises a slot in said lower surface for returning air received by said slot to a means for generating said horizontal flow and said curtain of air.

9. A load station as in claim 1 wherein said channel means comprises duct means for connecting to an air supply system of a clean room so that air from said air supply means is supplied to said channel means.

FIG. 1

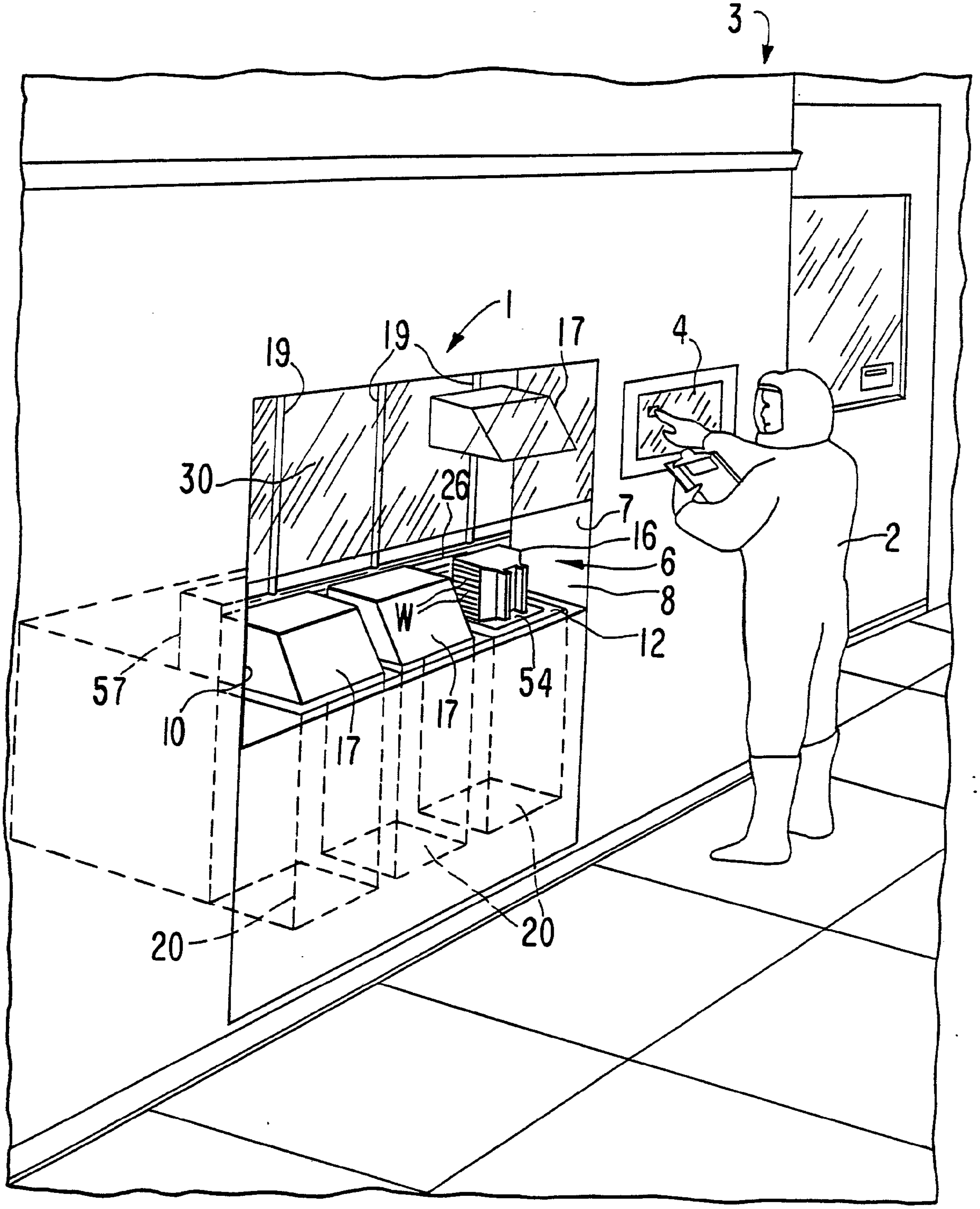


FIG.2

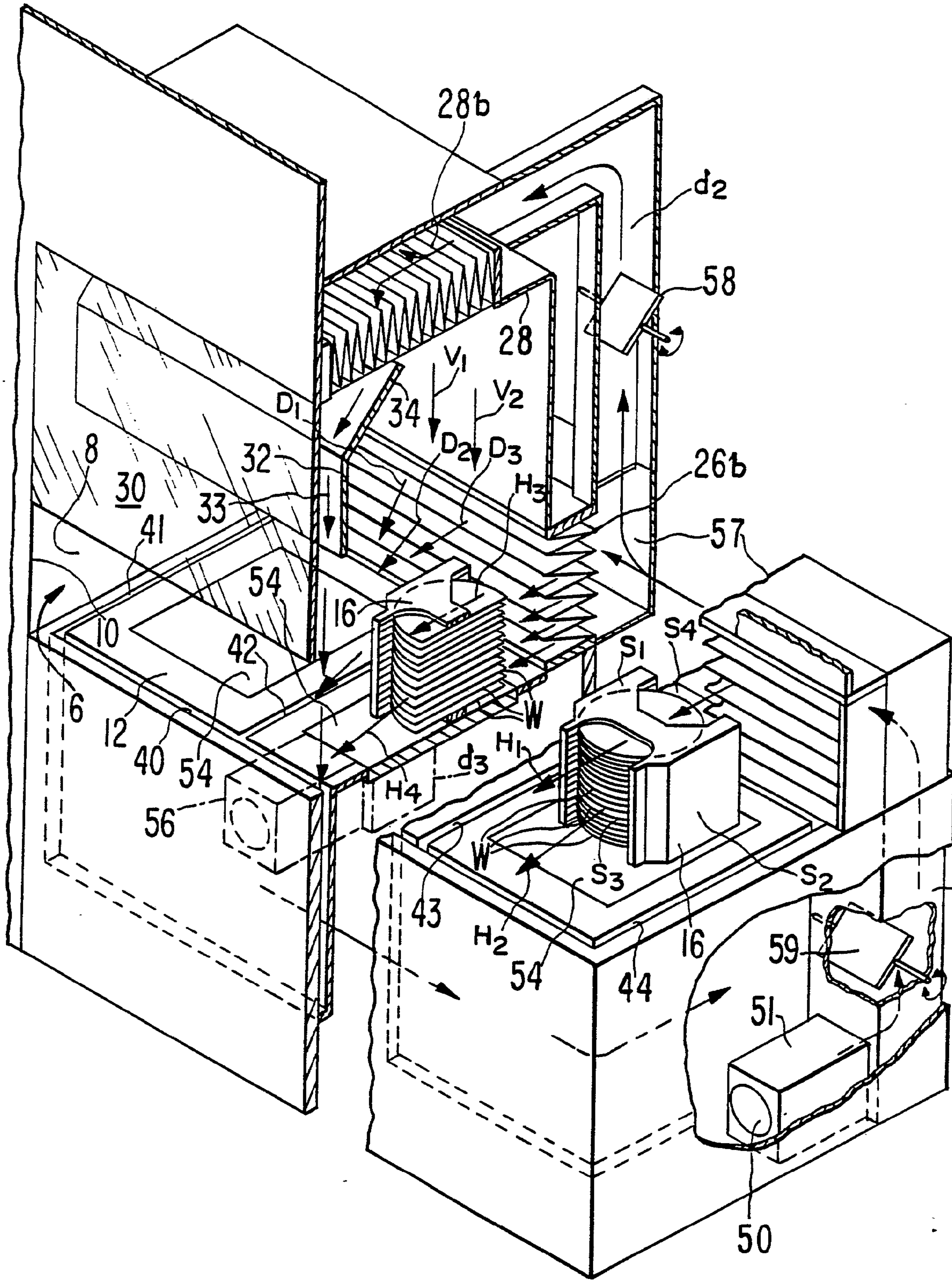

28b
d2
58
28
V1
V2
D1
34
D2
D3
8
30
32
33
26b
H3
57
41
54
16
10
S1
S4
42
W
6
12
40
54
H1
d3
H4
56
W
S3
S2
d1
43
H2
54
44
16
59
51
50

FIG.3